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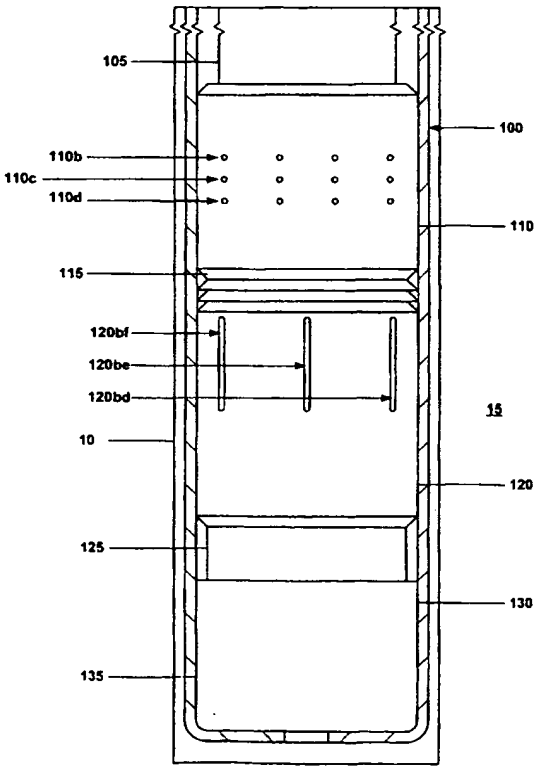
(54) Title: APPARATUS FOR RADIALLY EXPANDING TUBULAR MEMBERS INCLUDING A SEGMENTED EXPANSION CONE



(57) Abstract: An apparatus for radially expanding tubular members including a segmented expansion cone.

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APPARATUS FOR RADIALLY EXPANDING TUBULAR MEMBERS INCLUDING A SEGMENTED EXPANSION CONE

Background

This application claims the benefit of the earlier filed provisional application Serial No. 60/313,453, filed August 20, 2001, attorney docket no. 25791.59, the disclosure of which is incorporated by reference.

This application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001; (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001; (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001; and (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, the disclosures of which are incorporated herein by reference.

Background of the Invention

This invention relates generally to wellbore casings, and in particular to wellbore casings that are formed using expandable tubing.

Brief Description of the Drawings

Figs. 1a-1h are fragmentary cross-sectional illustrations of an embodiment of the placement of an apparatus for radially expanding a tubular member within a borehole within a subterranean formation.

Fig. 2 is a fragmentary cross-sectional illustration of the injection of a hardenable fluidic sealing material into the apparatus of Figs. 1a-1h.

Fig. 3 is a fragmentary cross-sectional illustration of the apparatus of Fig. 2 after injecting a fluidic material into the apparatus and seating a dart in the tubular dart seat.

Fig. 4 is a fragmentary cross-sectional illustration of the apparatus of Fig. 3 after continuing to inject a fluidic material into the apparatus thereby axially displacing the tension sleeve and thereby creating a segmented expansion cone for plastically deforming and radially expanding the expandable tubular member using the expansion segments.

Fig. 5 is a fragmentary cross-sectional illustration of the apparatus of Fig. 4 after continuing to inject a fluidic material into the apparatus thereby displacing the tubular locking sleeve from engagement with the locking member of the tubular locking collet.

Fig. 6 is a fragmentary cross-sectional illustration of the apparatus of Fig. 5 after continuing to inject a fluidic material into the apparatus thereby displacing the tubular support members, the tubular locking collet, the tubular locking sleeve, and the tubular tension sleeve upwardly in the axial direction thereby further plastically deforming and radially expanding the expandable tubular member.

Fig. 7 is a fragmentary cross-sectional illustration of the apparatus of Fig. 6 after continuing to inject a fluidic material into the apparatus thereby continuing to displace the tubular support members, the tubular locking collet, the tubular locking sleeve, and the tubular tension sleeve upwardly in the axial direction thereby further plastically deforming and radially expanding the expandable tubular member.

Detailed Description of the Illustrative Embodiments

Referring initially to Figs. 1a-1h, an embodiment of an apparatus and method for radially expanding a tubular member will now be described. As illustrated in Figs. 1a-1h, a wellbore 10 is positioned in a subterranean formation 15.

An apparatus 100 for radially expanding a tubular member may then be positioned within the wellbore 10 that includes a tubular support member 105 that defines a passage 105a. An end of the tubular support member 105 is coupled to an end of a tubular support member 110 that defines a passage 110a, a plurality of spaced apart radial passages 110b, 110c, and 110d, and includes a plurality of spaced apart internal flanges 110e, 110f, 110g, and 100h that are interleaved among the radial passages. The spaced apart radial passages 110b, 110c, and 110d may each include a plurality of radial passages distributed around the tubular support member 110 in the circumferential direction. Another end of the tubular support member 110 is coupled to an end of a tubular support member 115 that defines a passage 115a and includes a centrally positioned recessed portion 115b.

An end of a tubular support member 120 is coupled to another end of the tubular support member 115 that defines a passage 120a and a plurality of longitudinal slots 120ba, 120bb, 120bc, 120bd, 120be, and 120bf, and includes a plurality of internal arcuate expansion cone segments 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf. The expansion cone segments, 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf extend inwardly from the tubular support member 120 in the radial direction and include: (a) arcuate cylindrical segment end faces, 120caa, 210cba, 120cca, 120cda, 120cea, and 120cfa, that are substantially parallel to the longitudinal axis of the tubular support member, (b) upper inclined trapezoidal faces, 120cab, 120cbb, 120ccb, 120cdb, 120ceb, and 120cfb, that extend upwardly from the upper ends of the corresponding end faces to the tubular support member,

(c) lower inclined trapezoidal faces, 120cac, 120cbc, 120ccc, 120cdc, 120cec, and 120cfc, that extend downwardly from the lower ends of the corresponding end faces to the tubular support member, (d) side trapezoidal faces, 120cad, 120cbd, 120ccd, 120cdd, 120ced, and 120cfd, that extend from the sides of the corresponding end faces to the tubular support member, and (3) side trapezoidal faces, 120cae, 120cbe, 120cce, 120cde, 120cee, and 120cfe, that extend from the other sides of the corresponding end faces to the tubular support member. In an exemplary embodiment, the angle between the upper inclined trapezoidal faces, 120cab, 120cbb, 120ccb, 120cdb, 120ceb, and 120cfb, and the longitudinal direction is greater than the angle between the lower inclined trapezoidal faces, 120cac, 120cbc, 120ccc, 120cdc, 120cec, and 120cfc, and the longitudinal direction, respectively, in order to optimally provide radial expansion of the expansion cone segments. In an exemplary embodiment, the side faces, 120cae and 120cbd, 120cbe and 120ccd, 120cce and 120cdd, 120cde and 120ced, 120cee and 120cfd, and 120cfe and 120cad are substantially parallel in order to optimally provide a substantially continuous outer surface after the radial expansion of the expansion cone segments 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf.

An end of a tubular locking collet 125 is coupled to the other end of the other end of the tubular support member 120 that defines a passage 125a and includes a plurality of resilient locking collet members 125b. A tubular retaining member 130 that defines a passage 130a includes an internal recessed portion 130b at an end that is adapted to mate with and receive at least a portion of the locking collet members 125b of the tubular locking collet 125. Another end of the tubular retaining member 130 is coupled to an end of a shoe 135 that defines a passage 135a and an internal recess 135b and includes a conventional float valve 135c at an opposite end that permits fluids to be exhausted from the passage 135a outside of the apparatus 100 but prevents the flow of fluids into the passage and inside the apparatus.

A tubular dart seat 140 that defines a passage 140a and includes a recessed portion 140b is received within the passage 135a of the shoe 135 and is releasably coupled to the shoe by shear pins 145a and 145b. A tubular locking sleeve 150 that defines a passage 150a includes a locking member 150b that is received within and mates with the recesses, 135b and 140b, of the shoe 135 and dart seat 140, respectively, a conical locking flange 150c that locks the locking collet members 125b of the tubular locking collet 125 within the recessed portion 130b of the tubular retaining member 130, and an external flange 150d.

A tubular tension sleeve 155 is received within the tubular support members 110, 115, and 120, and the tubular locking collet 125 that defines a longitudinal passage 155a and longitudinally spaced radial passages 155b, 155c, and 155d includes a recessed portion 155e for movably receiving an end of the tubular locking sleeve 150, an internal flange 155f for engaging the external flange 150d of the tubular locking sleeve, an external flange 155g having a recessed portion 155ga, and longitudinally spaced apart external flanges 155h, 155i, and 155j. In an exemplary embodiment, each of the radial passages 155b, 155c, and 155d include a plurality of circumferentially spaced apart radial passages. In an exemplary embodiment, the external flanges 155h, 155i, and 155j are interleaved with the radial passages 155b, 155c, and 155d. In an exemplary embodiment, the external flanges 155h, 155i, and 155j are also interleaved with the internal flanges, 110e, 110f, 110g, and 110h of the tubular support member 110. In this manner, the internal flanges 110e, 110f, 110g, and 110h of the tubular support member 110 and the external flanges 155h, 155i, and 155j of the tubular tension sleeve 155 define annular chambers 160a, 160b, 160c, 160d, 160e, and 160f.

A tubular internal expansion cone 165 is received within and coupled to the recessed portion 155ga of the external flange 155g of the tubular tension sleeve 155. Cup seals 170a and 170b are coupled to the exterior of the recessed portion 115b of the tubular support member 115. An end of an expandable tubular member 175 is coupled to the shoe 135 for receiving the tubular support members 105, 110, 115, 120, and the tubular locking collet 125. The annulus between the tubular support member 115 and the expandable tubular member 175 is fluidicly sealed by the cup seals, 170a and 170b.

As illustrated in Figs. 1a-1h, the apparatus 100 is initially positioned within the wellbore 10 within the subterranean formation 15. The wellbore 10 may be vertical, horizontal, or any orientation in between. Furthermore, the wellbore 10 may be a tunnel for receiving a pipeline or a borehole for receiving a structural support. In addition, the wellbore 10 may include a preexisting wellbore casing.

As illustrated in Fig. 2, a hardenable fluidic sealing material 200 may then be injected into the apparatus 100 through the passages 105a, 110a, 155a, 150a, 140a, and 135a out of the float valve 135c into the annulus between the expandable tubular member 175 and the interior surface of the wellbore 10. In this manner, an annular layer of a sealing material may be formed around the expandable tubular member 175. In several alternative embodiments, the annular layer of the fluidic sealing material may be cured before or after radially expanding the expandable tubular member 175.

As illustrated in Fig. 3, a fluidic material 205 may be injected into the apparatus 100 through the passages 105a, 110a, 155a, 150a, 140a, and 135a. A conventional dart 210 may then be seated within the tubular dart seat 140 by introducing the dart into the injected fluidic material 205. Continued injection of the fluidic material 205 may then pressurize the passages 105a, 110a, and 155a thereby increasing the operating pressure in the passages and applying an axial downward force to the dart 210. As a result, the shear pins 145a and 145b may be sheared and the tubular dart seat 140 and the dart 210 may shift downward towards the float valve 135c. As a result, the locking member 150b of the tubular locking sleeve 150 may no longer be locked into the recess 135b of the shoe 135 by the tubular dart seat 140.

As illustrated in Fig. 4, continued injection of the fluidic material 205 may pressurize the passages 105a, 110a, and 155a thereby pressurizing and expanding the annular pressure chambers, 160a, 160c, and 160e. As a result, the tubular tension sleeve 155 may be displaced in the upward axial direction thereby driving the tubular internal expansion cone 165 into contact with the lower inclined trapezoidal faces 120cac, 120cbc, 120ccc, 120cdc, 120cec, and 120cfc of the expansion cone segments 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf, respectively, of the tubular support member 120. As a result, the expansion cone segments 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf of the tubular support member 120 are driven outwardly in the radial direction and the expandable tubular member 175 is thereby radially expanded and plastically deformed. In this manner, a segmented expansion cone for plastically deforming and radially expanding the expandable tubular member 175 may be formed within the wellbore 10 that includes the radially expanded expansion cone segments expansion cone segments 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf of the tubular support member 120.

As illustrated in Fig. 5, continued injection of the fluidic material 205 may further pressurize the passages 105a, 110a, and 155a, thereby further pressurizing and expanding the annular pressure chambers, 160a, 160c, and 160e. As a result, the tubular tension sleeve 155 may be further displaced in the upward axial direction thereby causing the internal flange 155f of the tubular tension sleeve to engage the external flange 150d of the tubular locking sleeve 150. As a result, the tubular locking sleeve 150 may be upwardly displaced

in the axial direction thereby releasing the conical locking flange 150c of the tubular locking sleeve from engagement with the locking collet members 125b of the tubular locking collet 125. As a result, the locking collet members 125b of the tubular locking collet 125 may be disengaged from the recessed portion 130b of the tubular retaining member 130. At this point the tubular locking collet 125 and the tubular locking sleeve 150 are no longer engaged with the tubular retaining member 130 and the shoe 135.

As illustrated in Fig. 6, continued injection of the fluidic material 205 may further pressurize the passages 105a, 110a, and 155a. As a result, the tubular support members 105, 110, 115, and 120, the tubular locking collet 125, the tubular locking sleeve 150, and the tubular tension sleeve 155 may be displaced upwardly in the axial direction thereby further plastically deforming and radially expanding the expandable tubular member 175.

As illustrated in Fig. 7, continued injection of the fluidic material 205 may further pressurize the passages 105a, 110a, and 155a. As a result, the tubular support members 105, 110, 115, and 120, the tubular locking collet 125, the tubular locking sleeve 150, and the tubular tension sleeve 155 may be further displaced upwardly in the axial direction thereby further plastically deforming and radially expanding the expandable tubular member 175. Furthermore, during the continued injection of the fluidic material 205, an annular region 215 between the tubular support member 120 and the expandable tubular member 175 below the sealing cups, 170a and 170b, may be pressurized thereby facilitating the upward axial displacement of the tubular support members 105, 110, 115, and 120, the tubular locking collet 125, the tubular locking sleeve 150, and the tubular tension sleeve 155.

In several alternative embodiments, the design and operation of the apparatus 100 is further provided substantially as disclosed in one or more of the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial

no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001; (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001; (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001; and (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, the disclosures of which are incorporated herein by reference.

In several alternative embodiments, the apparatus 100 may be operated for form or repair a wellbore casing, a pipeline, or a structural support.

An apparatus for forming a wellbore casing within a wellbore within a subterranean formation has been described that includes a tubular support member, an adjustable tubular expansion cone coupled to the tubular support member, an actuator coupled to the tubular support member for adjusting the size of the adjustable tubular expansion cone, a shoe releasably coupled to the adjustable tubular expansion cone, an expandable tubular member coupled to the shoe defining a longitudinal passage for receiving the tubular support member, the adjustable tubular expansion cone, and the actuator, and one or more sealing members for sealing the interface between the tubular support member and the expandable tubular member. In an exemplary embodiment, the adjustable tubular expansion cone includes a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate expansion cone segments interleaved among the longitudinal slots. In an exemplary embodiment, the actuator includes a first tubular member coupled to the tubular support member defining a plurality of first radial passage and including a plurality of internal flanges interleaved among the first radial passages, a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external flanges interleaved among the first and second radial passages and the internal flanges, and a tubular expansion cone coupled to the second tubular member for radially expanding the adjustable tubular expansion cone.

A method of forming a wellbore casing within a wellbore within a subterranean formation has also been described that includes positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore, increasing the size of the adjustable tubular expansion cone within the expandable tubular member, and plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone. In an exemplary embodiment, the increasing the size of the adjustable tubular expansion cone within the expandable tubular member includes positioning a tubular segmented expansion cone within the expandable tubular member, positioning a tubular expansion cone within the expandable tubular member, and displacing the tubular expansion cone relative to the tubular segmented expansion cone.

An apparatus for forming a wellbore casing within a wellbore within a subterranean formation has also been described that includes means for positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore, means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member, and means for plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone. In an exemplary embodiment, the means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member

includes means for positioning a tubular segmented expansion cone within the expandable tubular member, means for positioning a tubular expansion cone within the expandable tubular member, and means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

An adjustable expansion cone for plastically deforming and radially expanding a tubular member has also been described that includes an adjustable tubular expansion cone, and an actuator for adjusting the tubular adjustable expansion cone. In an exemplary embodiment, the adjustable tubular expansion cone includes a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate conical expansion cone segments interleaved among the longitudinal slots. In an exemplary embodiment, the actuator includes a first tubular member coupled to the adjustable tubular expansion cone defining a plurality of first radial passage and comprising a plurality of internal flanges interleaved among the first radial passages, a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external flanges interleaved among the first and second radial passages and the internal flanges, and a tubular expansion cone coupled to the second tubular member for radially expanding the tubular adjustable expansion cone.

A method of plastically deforming and radially expanding a tubular member has also been described that includes positioning an adjustable tubular expansion cone within the tubular member, and increasing the size of the adjustable tubular expansion cone within the expandable tubular member. In an exemplary embodiment, increasing the size of the adjustable tubular expansion cone within the tubular member includes positioning a tubular segmented expansion cone within the tubular member, positioning a tubular expansion cone within the tubular member, and displacing the tubular expansion cone relative to the tubular segmented expansion cone.

An apparatus for plastically deforming and radially expanding a tubular member has also been described that includes means for positioning an adjustable tubular expansion cone within the tubular member, and means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member. In an exemplary embodiment, the means for increasing the size of the adjustable tubular expansion cone within the tubular member includes means for positioning a tubular segmented expansion cone within the tubular member, means for positioning a tubular expansion cone within the tubular member, and means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

A tubular member has also been described that includes a tubular body defining a plurality of longitudinal slots, and a plurality of arcuate internal flanges. Each flange includes an arcuate cylindrical segment end face, trapezoidal side faces, an upper inclined trapezoidal side face, and a lower inclined trapezoidal side face.

It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, a conventional packer assembly may be substituted for the shoe 135.

Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

What is claimed is:

1. An apparatus for forming a wellbore casing within a wellbore within a subterranean formation, comprising:

a tubular support member;

an adjustable tubular expansion cone coupled to the tubular support member;

an actuator coupled to the tubular support member for adjusting the size of the adjustable tubular expansion cone;

a shoe releasably coupled to the adjustable tubular expansion cone;

an expandable tubular member coupled to the shoe defining a longitudinal passage for receiving the tubular support member, the adjustable tubular expansion cone, and the actuator; and

one or more sealing members for sealing the interface between the tubular support member and the expandable tubular member.

2. The apparatus of claim 1, wherein the adjustable tubular expansion cone comprises:

a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate expansion cone segments interleaved among the longitudinal slots.

3. The apparatus of claim 1, wherein the actuator comprises:

a first tubular member coupled to the tubular support member defining a plurality of first radial passage and comprising a plurality of internal flanges interleaved among the first radial passages;

a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external f langes interleaved among the first and second radial passages and the internal flanges; and

a tubular expansion cone coupled to the second tubular member for radially expanding the adjustable tubular expansion cone.

4. A method of forming a wellbore casing within a wellbore within a subterranean formation, comprising:

positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore;

increasing the size of the adjustable tubular expansion cone within the expandable tubular member; and

plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone.

5. The method of claim 4, wherein increasing the size of the adjustable tubular expansion cone within the expandable tubular member comprises:

positioning a tubular segmented expansion cone within the expandable tubular member;

positioning a tubular expansion cone within the expandable tubular member; and

displacing the tubular expansion cone relative to the tubular segmented expansion cone.

6. An apparatus for forming a wellbore casing within a wellbore within a subterranean formation, comprising:

means for positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore;

means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member; and

means for plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone.

7. The apparatus of claim 6, wherein the means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member comprises:

means for positioning a tubular segmented expansion cone within the expandable tubular member;

means for positioning a tubular expansion cone within the expandable tubular member; and

means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

8. An adjustable expansion cone for plastically deforming and radially expanding a tubular member, comprising:

an adjustable tubular expansion cone; and

an actuator for adjusting the tubular adjustable expansion cone.

9. The adjustable expansion cone of claim 8, wherein the adjustable tubular expansion cone comprises:

a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate conical expansion cone segments interleaved among the longitudinal slots.

10. The adjustable expansion cone of claim 8, wherein the actuator comprises:

a first tubular member coupled to the adjustable tubular expansion cone defining a plurality of first radial passage and comprising a plurality of internal flanges interleaved among the first radial passages;

a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external flanges interleaved among the first and second radial passages and the internal flanges; and

a tubular expansion cone coupled to the second tubular member for radially expanding the tubular adjustable expansion cone.

11. A method of plastically deforming and radially expanding a tubular member, comprising:

positioning an adjustable tubular expansion cone within the tubular member; and

increasing the size of the adjustable tubular expansion cone within the expandable tubular member.

12. The method of claim 11, wherein increasing the size of the adjustable tubular expansion cone within the tubular member comprises:

positioning a tubular segmented expansion cone within the tubular member;

positioning a tubular expansion cone within the tubular member; and

displacing the tubular expansion cone relative to the tubular segmented expansion cone.

13. An apparatus for plastically deforming and radially expanding a tubular member, comprising:

means for positioning an adjustable tubular expansion cone within the tubular member; and

means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member.

14. The apparatus of claim 13, wherein the means for increasing the size of the adjustable tubular expansion cone within the tubular member comprises:

means for positioning a tubular segmented expansion cone within the tubular member;

means for positioning a tubular expansion cone within the tubular member; and

means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

15. A tubular member, comprising:

a tubular body defining a plurality of longitudinal slots; and

a plurality of arcuate internal flanges, each flange comprising:

an arcuate cylindrical segment end face;

trapezoidal side faces;

an upper inclined trapezoidal side face; and

a lower inclined trapezoidal side face.

16. An apparatus for forming a wellbore casing within a wellbore within a subterranean formation, comprising:

a tubular support member;

an adjustable tubular expansion cone coupled to the tubular support member, comprising:

a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate expansion cone segments interleaved among the longitudinal slots;

an actuator coupled to the tubular support member for adjusting the size of the adjustable tubular expansion cone, comprising:

a first tubular member coupled to the tubular support member defining a plurality of first radial passage and comprising a plurality of internal flanges interleaved among the first radial passages;

a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a

plurality of external flanges interleaved among the first and second radial passages and the internal flanges; and

a tubular expansion cone coupled to the second tubular member for radially expanding the adjustable tubular expansion cone;

a shoe releasably coupled to the adjustable tubular expansion cone;

an expandable tubular member coupled to the shoe defining a longitudinal passage for receiving the tubular support member, the adjustable tubular expansion cone, and the actuator; and

one or more sealing members for sealing the interface between the tubular support member and the expandable tubular member.

17. A method of forming a wellbore casing within a wellbore within a subterranean formation, comprising:

positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore;

increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

positioning a tubular segmented expansion cone within the expandable tubular member;

positioning a tubular expansion cone within the expandable tubular member; and

displacing the tubular expansion cone relative to the tubular segmented expansion cone; and

plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone.

18. An apparatus for forming a wellbore casing within a wellbore within a subterranean formation, comprising:

means for positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore;

means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

means for positioning a tubular segmented expansion cone within the expandable tubular member;

means for positioning a tubular expansion cone within the expandable tubular member; and

means for displacing the tubular expansion cone relative to the tubular segmented expansion cone; and

means for plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone.

19. An adjustable expansion cone for plastically deforming and radially expanding a tubular member, comprising:

an adjustable tubular expansion cone, comprising:

a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal

arcuate conical expansion cone segments interleaved among the longitudinal slots; and

an actuator for adjusting the tubular adjustable expansion cone, comprising:

a first tubular member coupled to the adjustable tubular expansion cone defining a plurality of first radial passage and comprising a plurality of internal flanges interleaved among the first radial passages;

a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external flanges interleaved among the first and second radial passages and the internal flanges; and

a tubular expansion cone coupled to the second tubular member for radially expanding the tubular adjustable expansion cone.

20. A method of plastically deforming and radially expanding a tubular member, comprising:

positioning an adjustable tubular expansion cone within the tubular member; and

increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

positioning a tubular segmented expansion cone within the tubular member;

positioning a tubular expansion cone within the tubular member; and

displacing the tubular expansion cone relative to the tubular segmented expansion cone.

21. An apparatus for plastically deforming and radially expanding a tubular member, comprising:

means for positioning an adjustable tubular expansion cone within the tubular member; and

means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

means for positioning a tubular segmented expansion cone within the tubular member;

means for positioning a tubular expansion cone within the tubular member; and

means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

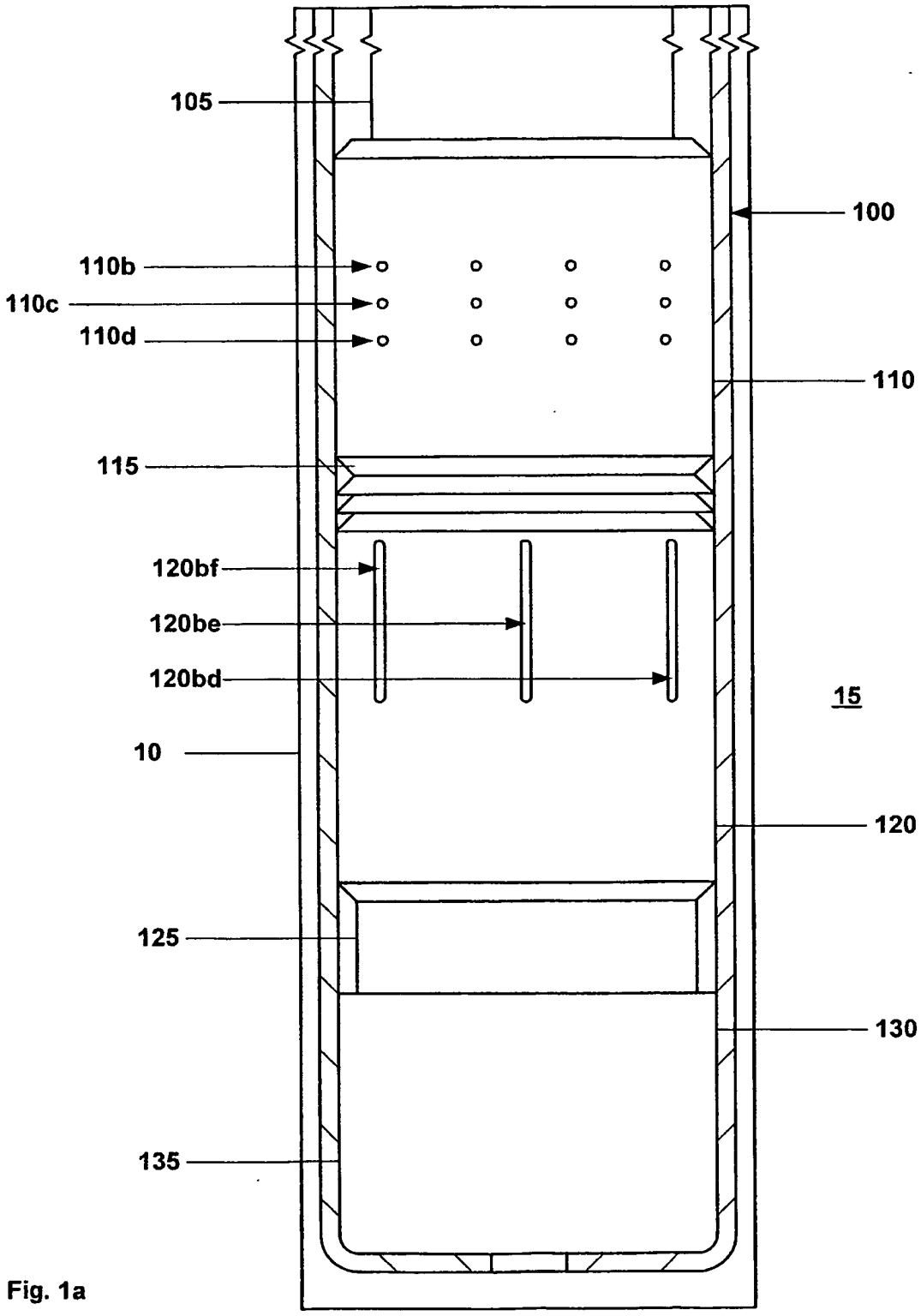
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Fig. 1a

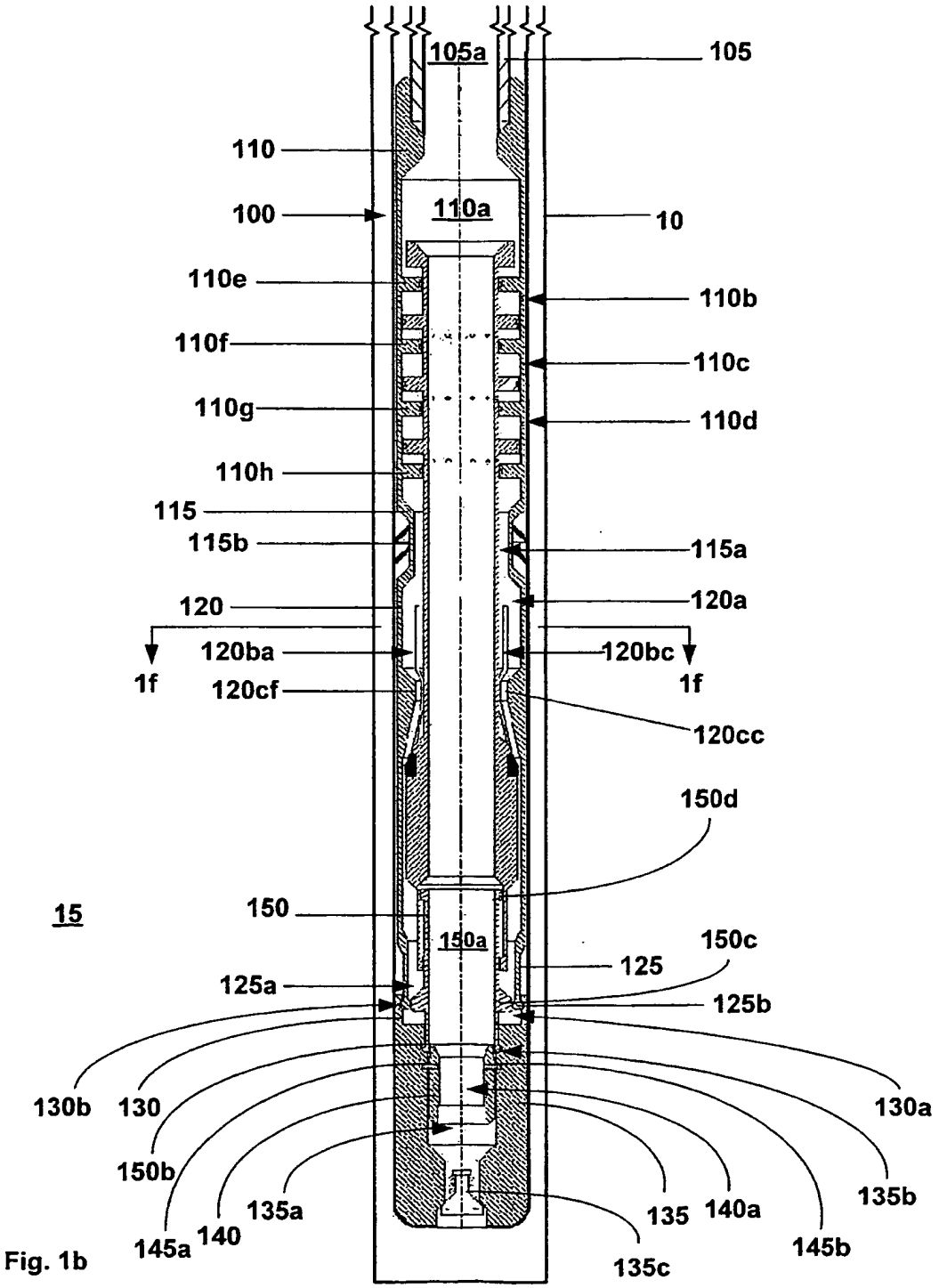
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Fig. 1b

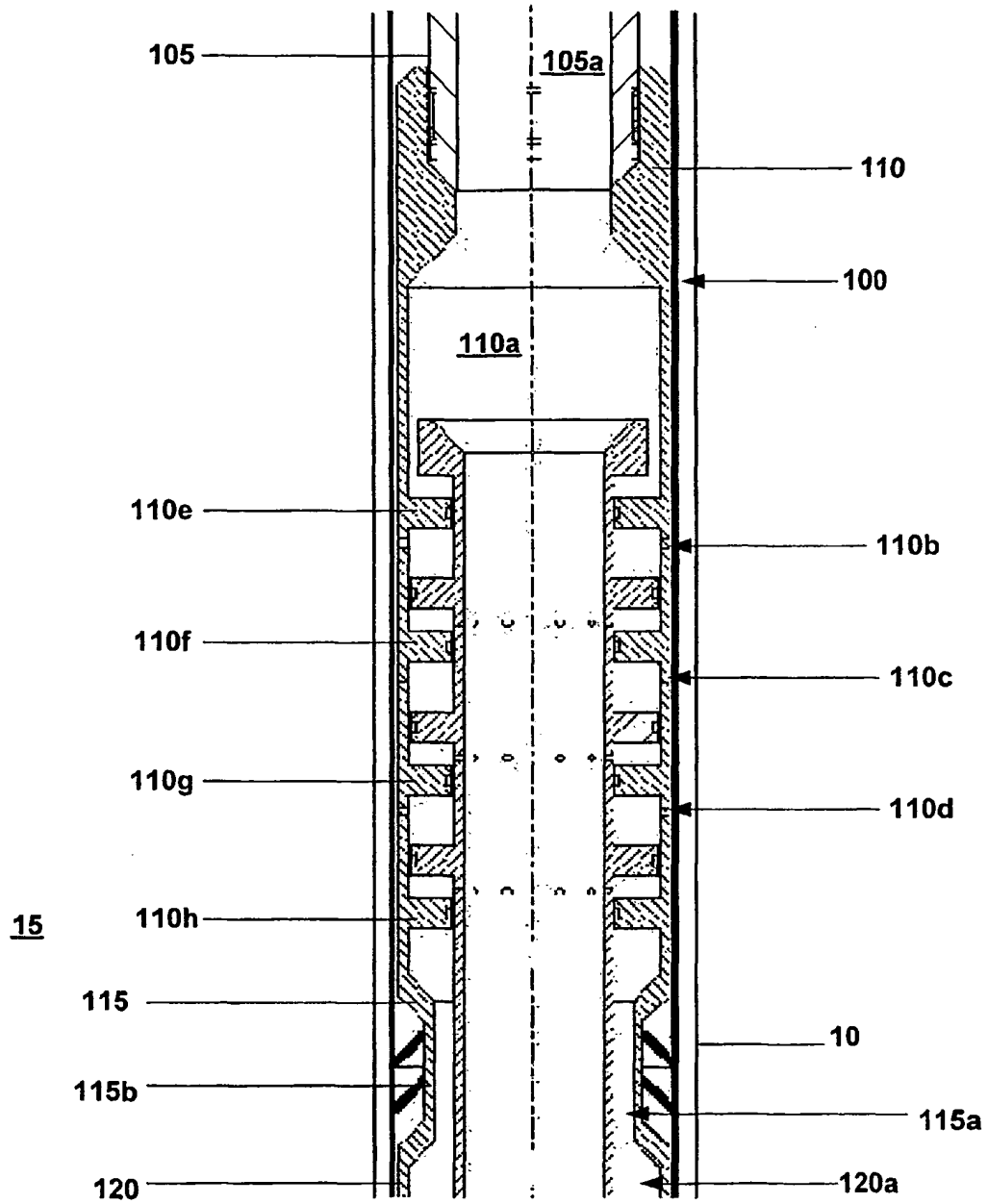
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Fig. 1c

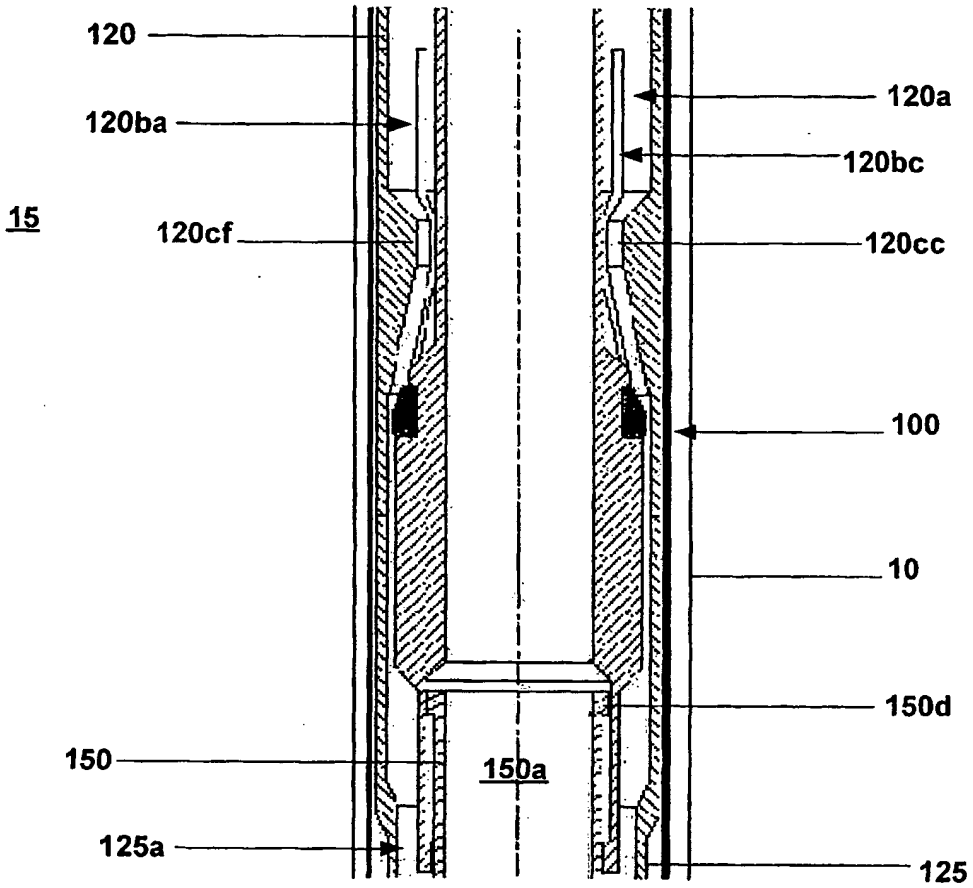
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Fig. 1d

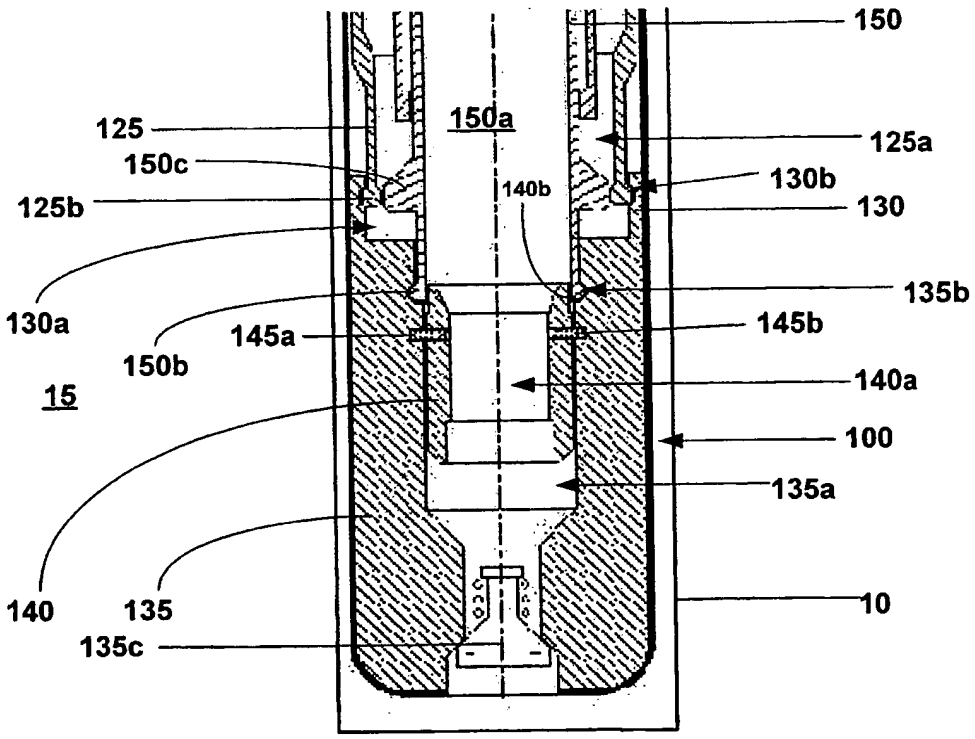
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Fig. 1e

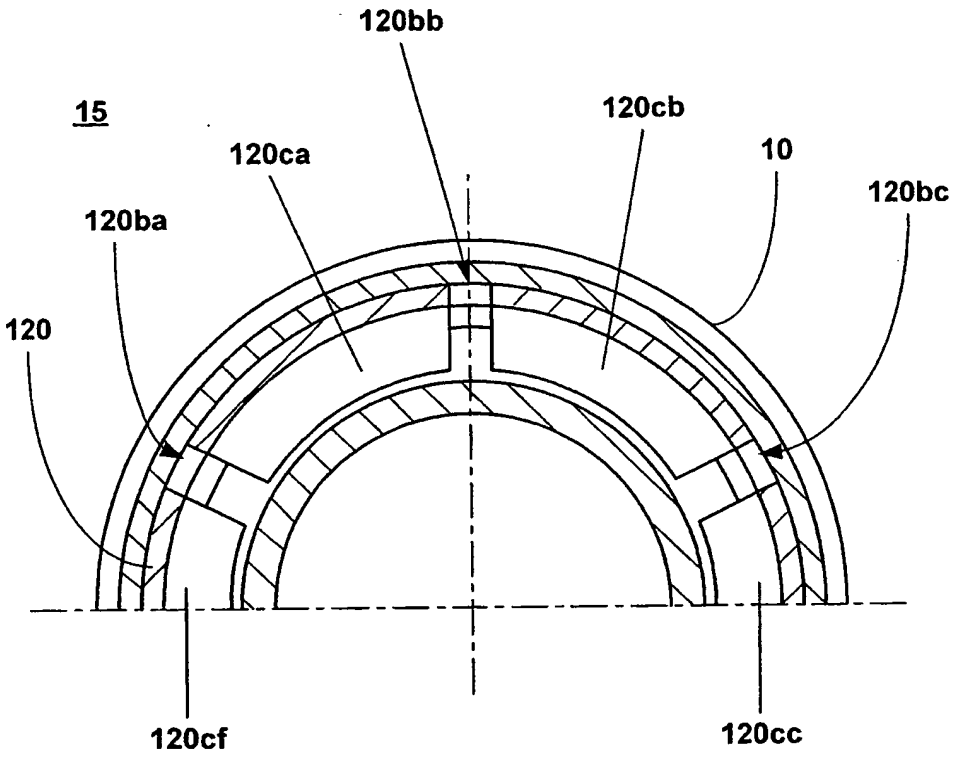

Fig. 1f

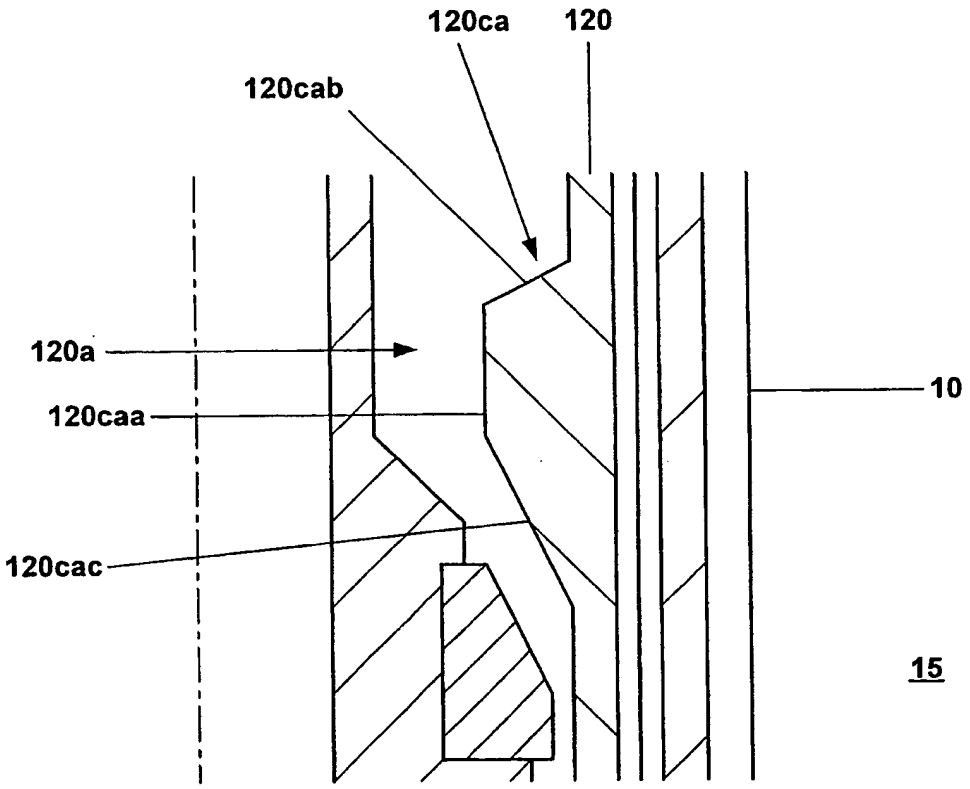

Fig. 1g

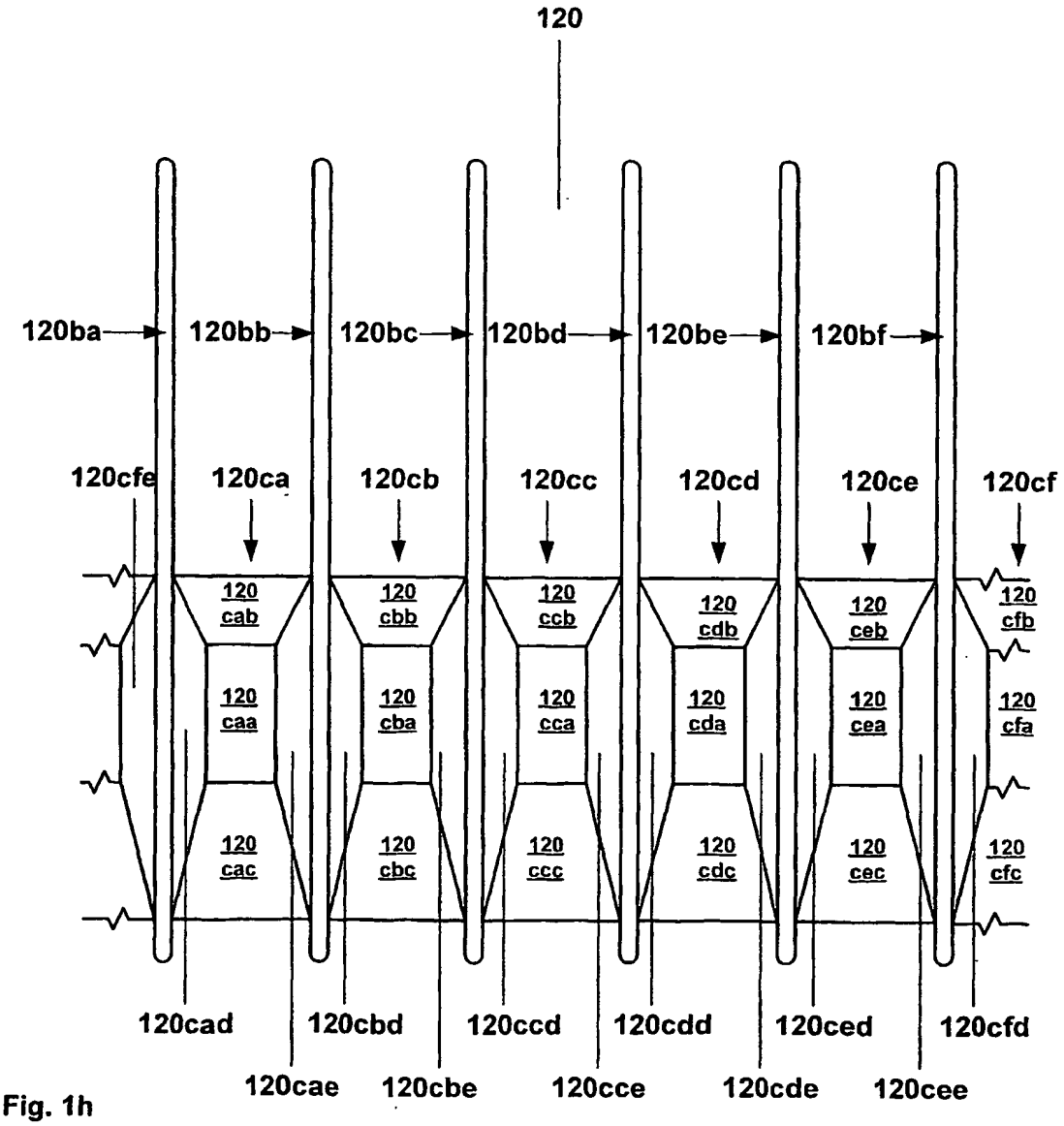
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Fig. 1h

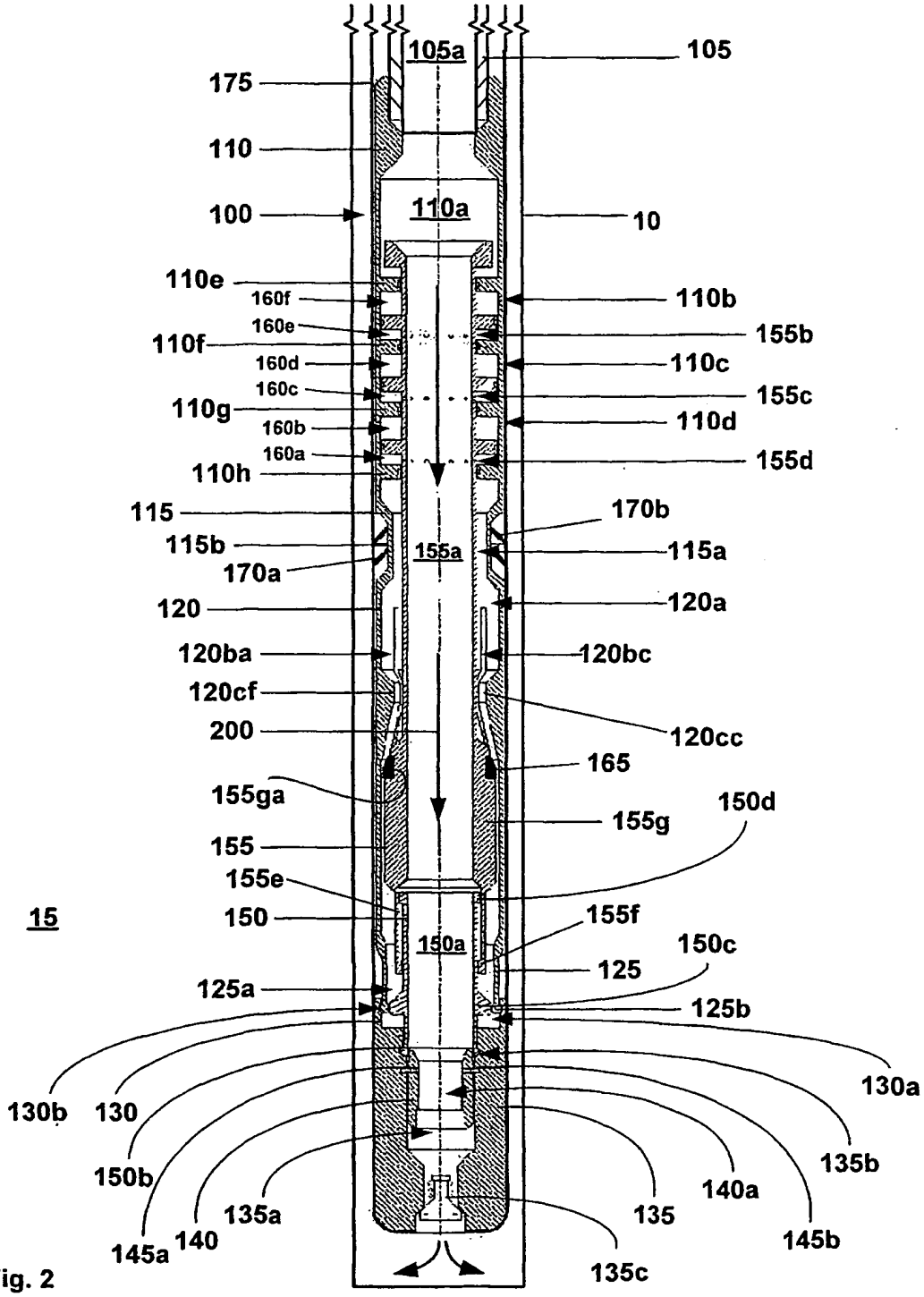
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Fig. 2

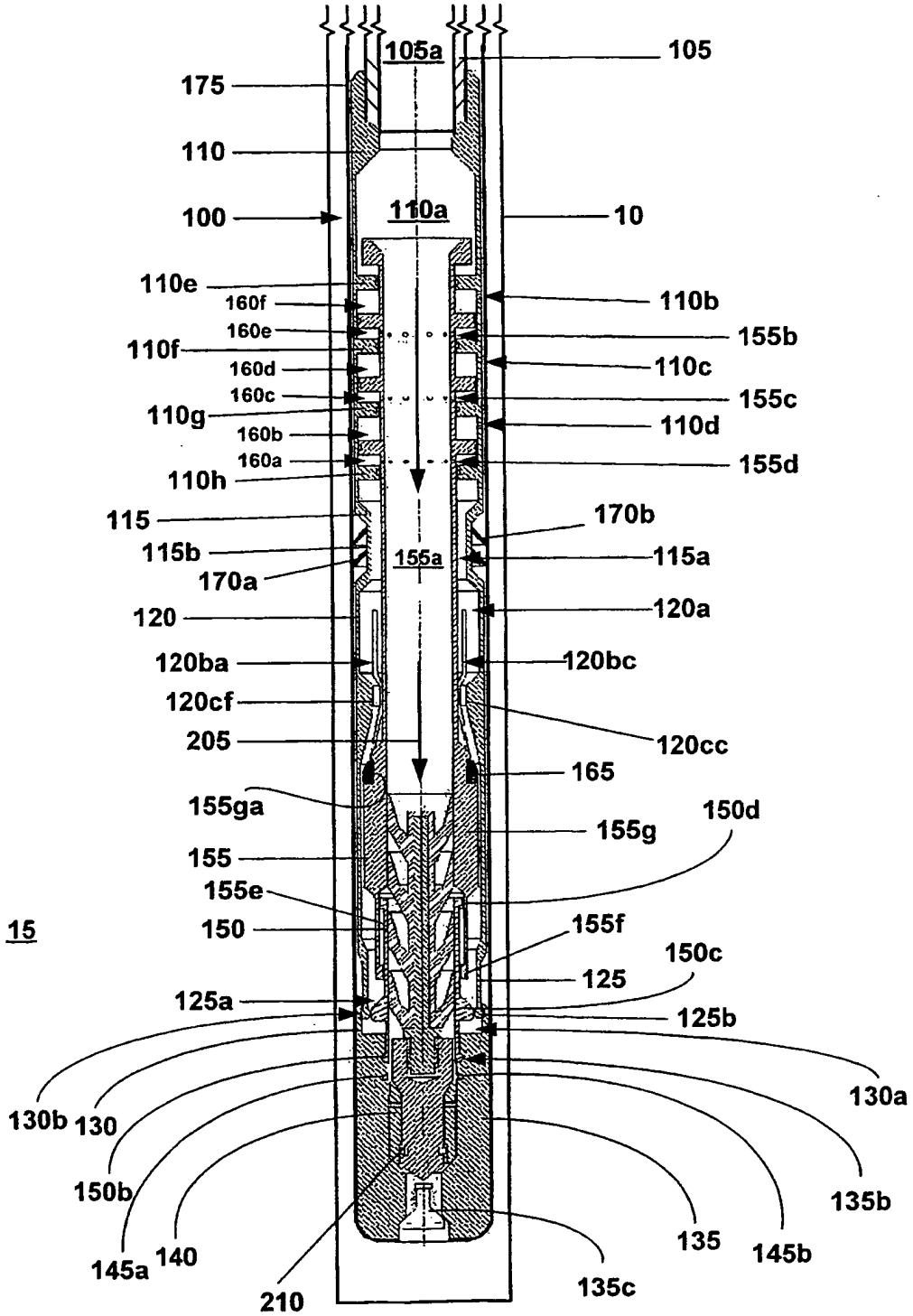
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Fig. 3

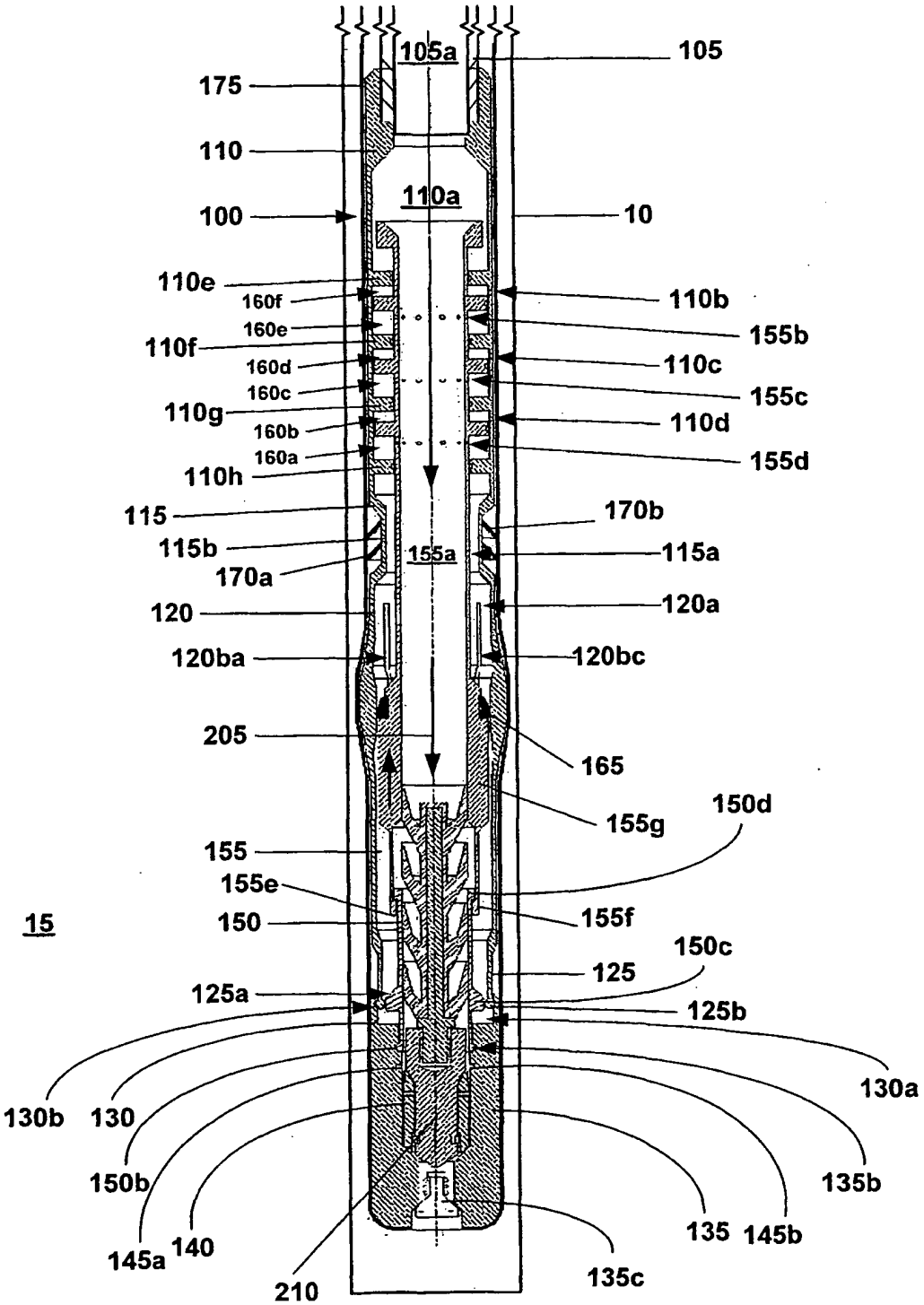
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Fig. 4

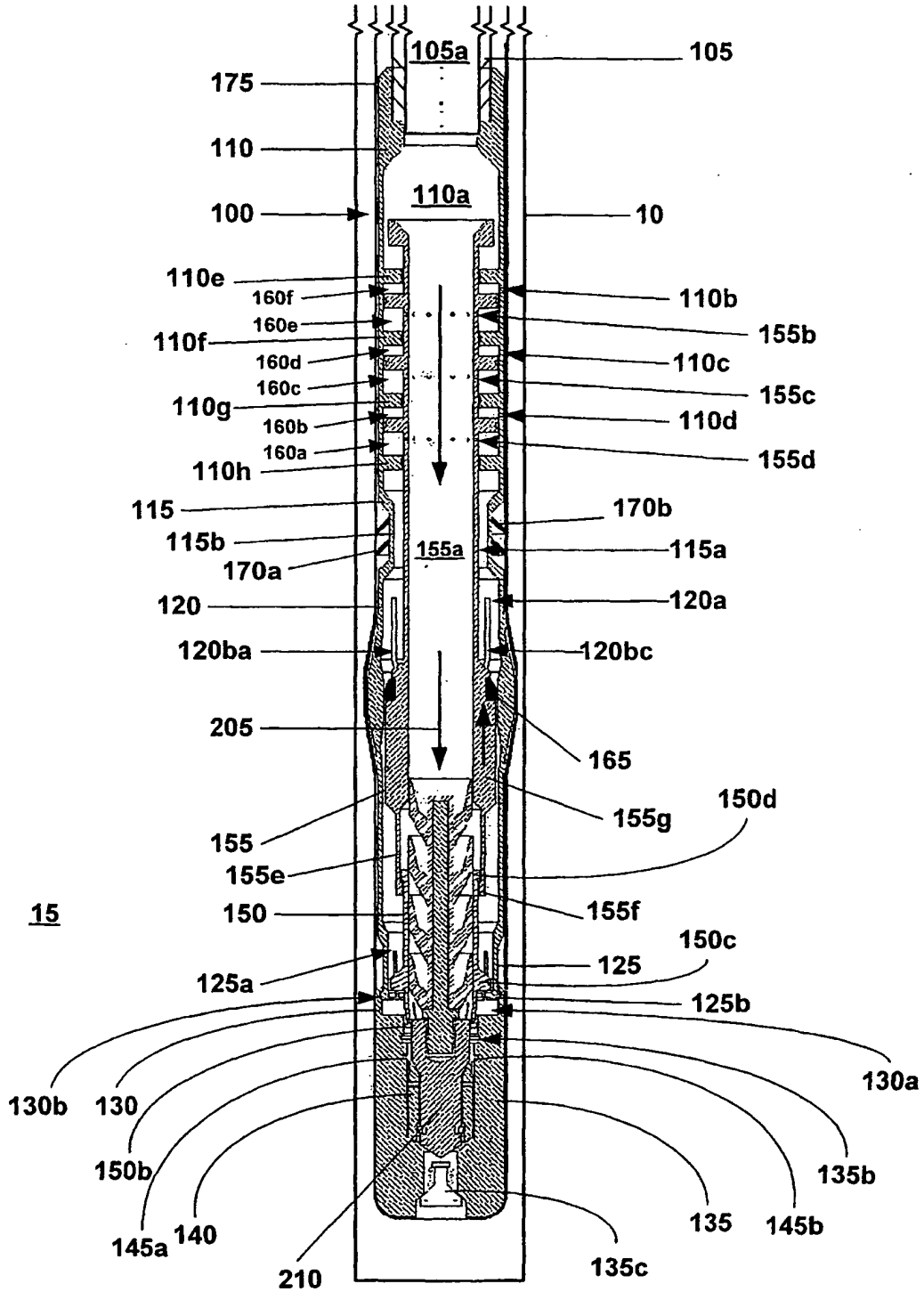
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Fig. 5

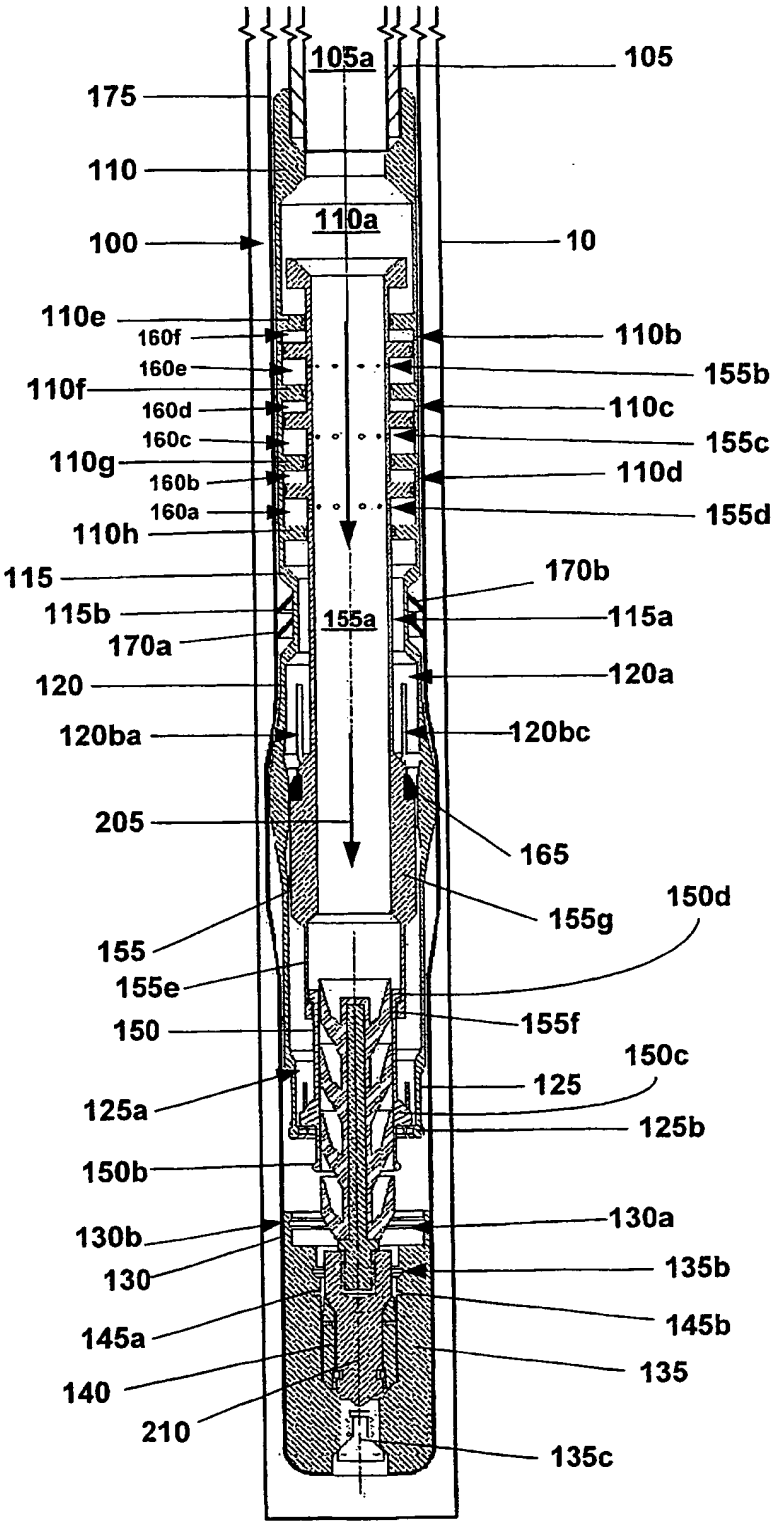
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Fig. 6

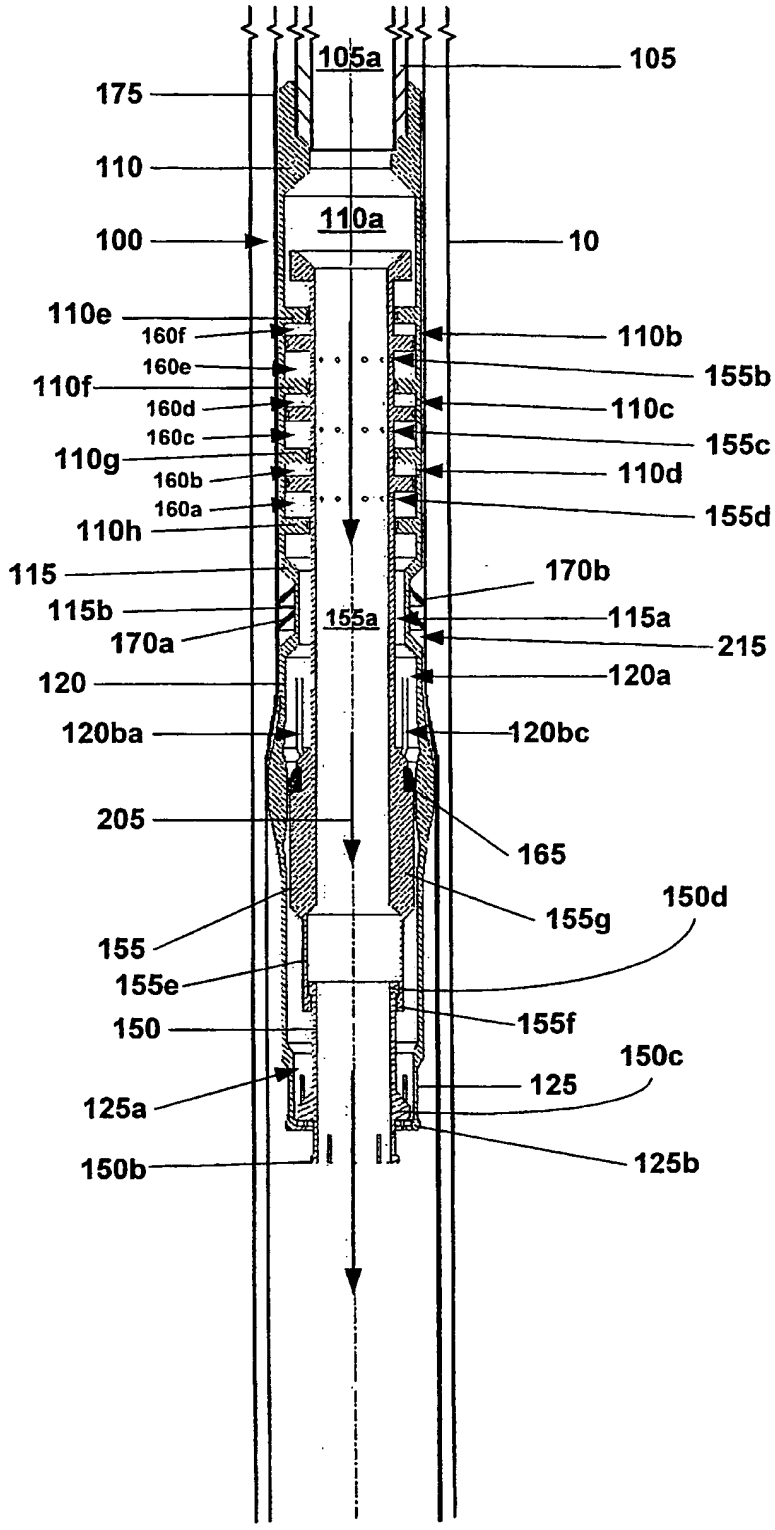
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Fig. 7